Safe Drinking WATER

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Sources • Quality • Laws • Protection • Testing

Safe Drinking Water

Office of Drinking Water
Division of Environmental Health
Washington State Department of Health

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Introduction

This booklet is designed to educate consumers about public drinking water. It provides general information regarding:

- Regulations that govern public water systems;
- Water sources;
- Water quality;
- Health effects;
- Water treatment; and
- Resources for more information.

Safe drinking water is a resource that often is taken for granted. It is so abundant and inexpensive that we fill our glasses without a second thought about how the water got to our taps. Each person uses approximately 168 gallons a day, with each gallon costing less than 1/16 of a cent. We don't realize that our water is safe and reliable only because we enjoy some of the best water in the world. And we often don't realize that water is a resource that must be protected.

Drinking water has not always been safe in this country. Less than a century ago, serious illnesses such as cholera and typhoid fever were frequently transmitted by drinking water. Then, in 1908, chlorine was introduced as a disinfectant in U.S. water supplies to control disease-causing microorganisms. By mid-century, the number of deaths from typhoid fever and cholera had dropped significantly.

Now that we have the technology to protect our water supplies, disease epidemics are rarely spread by drinking water in this country. The challenge of keeping our drinking water safe, however, is far from over. For example, water supplies can be contaminated with naturally occurring chemicals as well as with human-made chemicals common to our industrial society, such as herbicides or pesticides. We have also increased our ability to measure low levels of chemicals in water. As a result, we have become aware that long-term exposure to some chemicals, even at low levels, can pose a health risk and must be controlled.

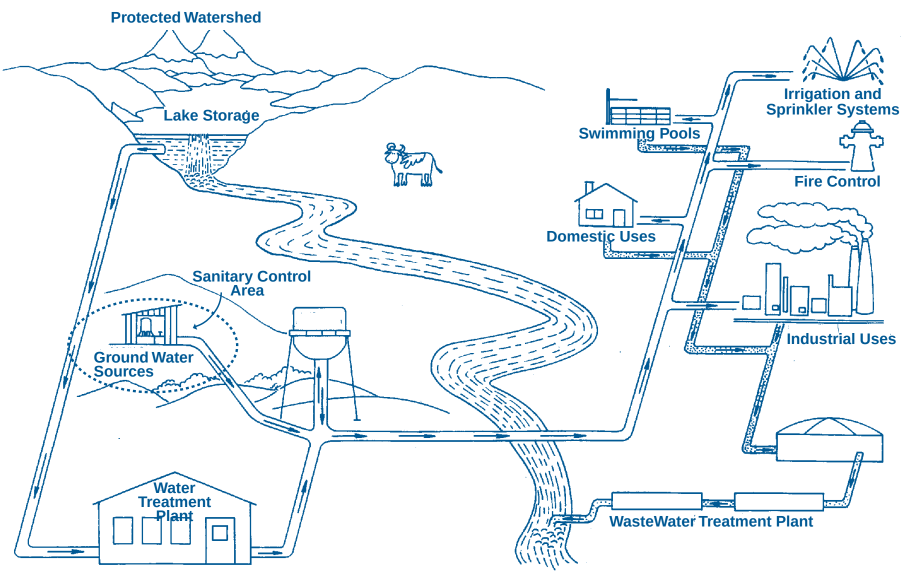
Fortunately, many people are working together to bring you safe drinking water. Some work directly for public water systems, while others work for laboratories and companies that supply various services to water systems, and some are employees of government agencies that oversee and regulate public water systems. All of these people are an essential part of the system that provides you with safe drinking water.

What is a Public Water System?

A public water system is any system that provides water for human consumption and serves more than one single-family residence or more than four residences on a single family farm. A typical system has many components. These include a source of supply (well, spring, or river), pumps, reservoirs, storage tanks, treatment plants, water mains, and other distribution pipes, control valves, fire hydrants, flow meters, etc. Figure 1 shows the components of a typical water system from source to users.

Examples of public water systems include municipal systems (cities, towns, and water districts) and small community systems serving two or more homes. Schools, restaurants, motels, campgrounds, churches, and businesses are also considered public water systems in most cases.

Figure 1. Typical Water System



Regulation of Drinking Water

Agencies Working to Keep Drinking Water Safe

Public water systems must comply with laws designed to protect drinking water quality and public health. Table 1 lists the agencies that regulate public water systems and related issues in Washington.

Table 1. Drinking Water Responsibilities of Government Agencies

Environmental Protection Agency	■ Sets national drinking water standards ■ Provides money and assistance to states ■ Conducts drinking water research and training ■ Administers other federal environmental laws
Department of Health Drinking Water Program	■ Regulates public water systems in Washington ■ Develops state drinking water standards ■ Approves engineering documents, oversees water system operations and water quality monitoring ■ Tests and certifies waterworks operators ■ Administers a planning program to coordinate and improve water system facilities and operations
Department of Ecology	■ Regulates water withdrawals and well construction ■ Administers ground water protection programs ■ Administers pollution control programs ■ Oversees hazardous waste clean-up activities ■ Certifies environmental and drinking water labs
Utilities & Transportation Commission	■ Regulates private investor-owned utilities ■ Rules on requests for rate increases and capital improvements ■ Assists consumers with utility disputes ■ Coordinates with Department of Health on utility improvements and operations
Department of Agriculture	■ Regulates application of pesticides
Local Health Agencies	■ Regulate most on-site sewage systems (septic systems) ■ Many regulate small public water systems ■ Most conduct a limited number of drinking water tests (primarily bacteriological tests)
Local Building/ Planning Agencies	■ Most administer plumbing codes and issue building and occupancy permits ■ Approve subdivisions and make land use decisions ■ Coordinate with health agencies to ensure that water and wastewater issues are addressed.

Federal Laws and Washington's Drinking Water Program

The Federal Safe Drinking Water Act

Washington's drinking water program is based primarily on federal laws. The major federal laws are the Safe Drinking Water Act of 1974 and its amendments of 1986 and 1996.

Drinking water standards were first established under the Public Health Service Act in the early 1900s. These standards regulated both the microbiological and chemical quality of drinking water, but applied only to water supplies serving interstate transportation (such as boats and trains). The standards introduced the concept of safe limits for drinking water contaminants.

In 1974, Congress passed the federal Safe Drinking Water Act (SDWA). This law was designed to protect drinking water across the nation and provide consistency among states. The SDWA greatly expanded federal responsibility for drinking water by extending standards to all public water systems nationwide (serving 15 or more connections or 25 or more people).

Under the SDWA, the U. S. Environmental Protection Agency (EPA) had the responsibility of developing national standards for known or suspected drinking water contaminants. The law also required drinking water systems to notify the public when standards were not being met.

States were given the authority to set drinking water standards equal to or more stringent than EPA's. EPA also assumed administration of drinking water programs in states not willing or able to establish and enforce standards. A dual system of state-federal protection of drinking water had begun.

The Safe Drinking Water Act Amendments

Congress amended the SDWA in 1986. The amendments contain specific deadlines for federal, state, and utility action related to drinking water. EPA is required to set standards for numerous contaminants and adopt regulations setting treatment requirements for public water systems.

In addition, the amendments prohibit the use of lead in new plumbing and in repairs to existing systems. A program to protect well sources from contamination is also included. Enforcement of drinking water laws by state and federal agencies is the primary emphasis of the amendments.

In 1996, Congress amended the Safe Drinking Water Act to emphasize sound science and risk-based standard setting, small water supply system flexibility and technical assistance, community-empowered source water assessment and protection, public right-to-know, and water system infrastructure assistance through a multi-billion-dollar state revolving loan fund.

Trends in Drinking Water Laws

State drinking water laws have undergone major changes as a result of the amendments. More standards are being established and some existing standards are becoming more stringent. This trend will likely continue as more information is developed on health effects, and as lab-testing techniques become more sophisticated.

These changes impact everyone:

- For water systems, the new requirements mean increased costs for treatment, more sampling, and increased record keeping and notification. More emphasis on management will be necessary.
- For regulatory agencies, new programs must be developed, staffed, and implemented. Additional enforcement support will also be needed. Laboratory capability must be developed and maintained to provide the added testing services needed.
- For consumers, new requirements will mean greater health protection and confidence in their water supplies. Water bills may increase in response to increased utility cost.

Primacy and Partnership

Federal law enables states to have primary responsibility for administering and enforcing the SDWA. This is called primacy. To obtain primacy, EPA must be assured the state meets certain criteria, including adoption of regulations at least as stringent as EPA's and development of state laboratory capability.

Primacy was awarded to Washington State in 1978. The State Board of Health and Department of Health (DOH) are partners in developing and enforcing state drink water regulations. DOH also works closely with EPA to carry out the state's program.

The state also has a partnership with local health agencies similar to the partnership between EPA and the state. Although responsibilities vary, local health agencies use state standards to regulate and assist small water systems.

Washington's Drinking Water Program

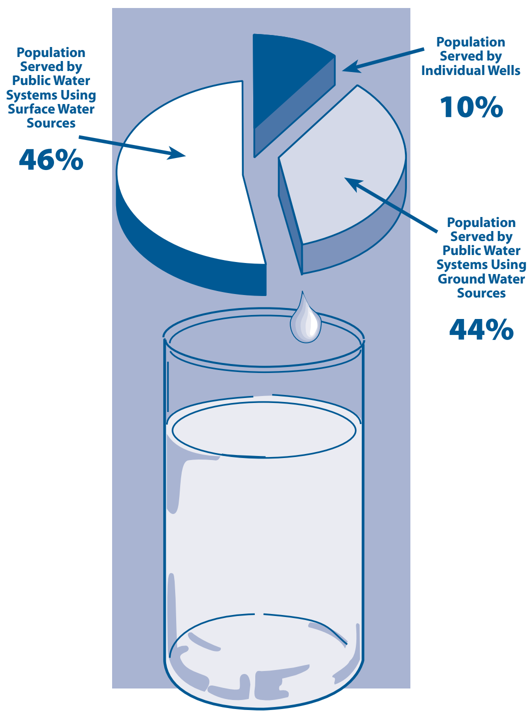
The mission of the state drinking water program is to protect public health by assuring safe and reliable drinking water. To accomplish this, environmental scientists, engineers, planners, and other technical support personnel in both state and local health agencies regulate over 18,000 public water systems in Washington State.

Here are some statistics about Washington's drinking water:

- Approximately 90 percent of the state's residents are served by public water systems.
- 60 percent of these residents are served by systems using surface water sources (rivers, lakes, and streams). Cities such as Aberdeen, Seattle, Bremerton, Everett, Bellingham, Pasco, Walla Walla, and Yakima rely primarily on surface water.
- The remaining 40 percent are served by systems using wells. Cities that rely on wells include: Spokane, Wenatchee, Ellensburg, Renton, Auburn, Puyallup, and Vancouver.

See Figure 2 for a breakdown of population served by different sources of drinking water in Washington.

**Figure 2.
Washington State Population
Served by Water System Type**



General Requirements for Public Water Systems

Public water systems of all sizes must comply with comprehensive regulations such as those found in Washington Administrative Code chapters 246-290 and 291, and county and municipal codes. These requirements cover many topics ranging from source approval to long-range planning.

Before facilities can be constructed, a public water system must obtain state or local health agency approval of its source. Once a source has been approved, DOH engineers or local health agency staff review and approve construction documents to ensure that water systems are properly designed and constructed. Once constructed, public water suppliers are responsible for treatment, operation, maintenance, and monitoring water quality.

Drinking Water Standards/Monitoring

Public water systems must provide drinking water that meets state standards. Standards define the allowable, safe limits of contaminants in drinking water. There are standards for microbiological and chemical contaminants as well as certain physical characteristics of the water. These are discussed in more detail later.

To prove that standards are consistently being met, public water systems are required to routinely test their water. Water samples must be collected from both the source and the distribution system.

Public Notification

The purpose of public notification is to assure that consumers are informed about the quality of their drinking water. Consumers have the right to know of problems affecting their drinking water. System operators must notify customers of violations of health-related drinking water quality standards.

Violations are separated into three tiers based on potential health impact:

- **Tier 1:** Acute health concerns require notification within 24 hours.
- **Tier 2:** Chronic health concerns require notification within 30 days
- **Tier 3:** Reporting and monitoring violations require notification within 365 days.

Drinking Water Sources

Hydrologic Cycle

From the beginning of time, water has been constantly circulating between the atmosphere, ocean, and land. This circulation is known as the hydrologic cycle. Moisture from the oceans evaporates, condenses, and falls to the earth as rain or snow, and then returns to the oceans. Figure 3 illustrates this process. As can be seen, some of the precipitation that falls to the earth has the potential to become drinking water.

Types of Sources

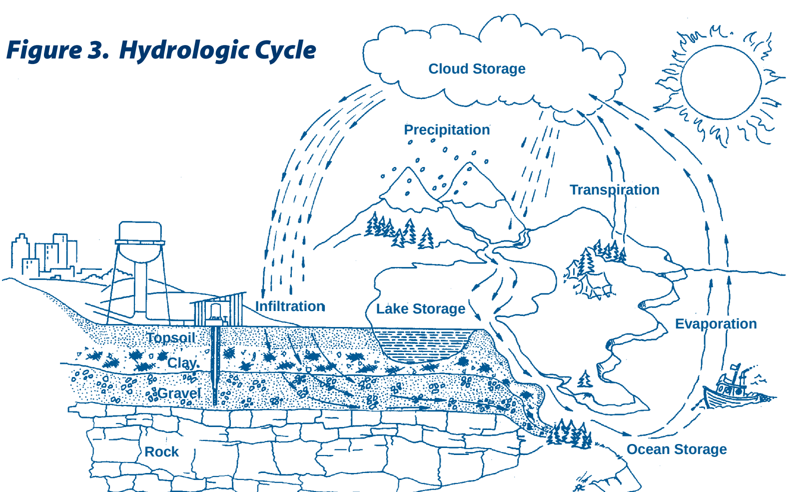
Drinking water comes from two types of sources: ground or surface water. Groundwater exists underground and is available from wells. Surface water is located in rivers, lakes, and streams. Spring sources are generally considered groundwater, but may be influenced by surface water.

The quality and quantity of water are two important factors to consider in the selection of a drinking water source. For public water systems, the water must be obtained by the highest quality source feasible.

In general, groundwater tends to be of higher and more uniform quality than surface water. So from a public health standpoint, wells are preferred over surface water. However, with the development of groundwater, little may be known about water quality or quantity until the well is drilled.

Before a drinking water source can be approved by DOH, a system owner may need to obtain a water right permit.

Figure 3. Hydrologic Cycle



Water Rights

Under state water law, rights to the use of water do not automatically go along with land ownership. It is often necessary to obtain a water right to develop a drinking water source.

The Department of Ecology (Ecology) supervises water rights and water usage in the state of Washington. Systems planning to develop either a surface water source or a well must apply to Ecology for a water right permit. Wells that will use less than 5,000 gallons per day or will be used for non-commercial irrigation of a half acre, or less, are exempt from the permit requirement. Contact your regional Ecology office for water right information.

Source Development

Proper well location and construction can help ensure that an adequate quantity of high quality drinking water is available at all times to a public water system. Depending on water right availability and the unique aspects of an area's water resources, development of a groundwater well is often considered the most suitable choice for a new public water supply. The development of new surface sources, springs, or shallow wells is generally discouraged. These types of sources are considered at greater risk to contamination than a properly located and constructed well. This greater risk means that there are more stringent requirements for approval, treatment, and water quality sampling associated with these types of sources.

Despite a water system's efforts toward implementing water use efficiency measures, there may develop situations where water supply needs exceed the capacity of an area's groundwater resource. In such cases, the development of a surface water source may be the most suitable choice. However, when initial construction costs and ongoing treatment, operation, and maintenance costs are considered, surface supplies are typically more costly than groundwater supplies.

When a surface water source is developed, treatment must be provided. Treatment consists of filtration and disinfection, and involves sampling, recording, and submitting numerous daily test results to DOH. Only under very specific circumstances may a surface water source be permitted to supply the public with disinfection as the only mode of treatment (i.e., no filtration). All public water systems utilizing surface water are required to employ a certified water treatment plant operator.

Well Location

Drinking water regulations require public water systems to obtain water from the highest quality source possible. Locating a drinking water source requires careful consideration of many factors.

The area surrounding a public water supply well must be free of all potential sources of contamination, such as sewer lines or other sewage conveyance or disposal facilities, manure, fuels, pesticides, and paints. In addition, land ownership, covenants, and/or easements must be secured as a means of prohibiting land uses around a public water supply well that might threaten future water quality.

Regulations require public water systems to maintain a minimum sanitary control area to prevent future land uses from threatening the quality of water delivered from a public water supply. A radius of 100 feet around a well and 200 feet around a spring is the minimum sanitary control area required, unless reasonable engineering justification for a smaller area is provided. In some cases, larger areas may be required by DOH or the local health jurisdiction to protect drinking water. Prospective well owners should contact their local health jurisdiction to schedule a well site inspection, and to find out if more stringent requirements apply in a particular well location.

Source Construction

Surface and underground conditions must be taken into account when considering the development of a groundwater well as a public water supply. In addition to appropriate well location and securing legal protection of the area around the well, the most effective means of securing a protected source of groundwater is to tap into a body of groundwater (i.e., an aquifer) that is located beneath a layer of clay, hard pan, solid rock, or other impermeable material, and to seal the well casing into this impermeable layer.

Questions about the standards for well construction can be answered by Ecology. If you own an existing well but do not have a copy of the well's construction, Ecology also maintains statewide well construction information (well logs).

Despite efforts at securing a protected groundwater supply, the prevailing water quality in a particular aquifer may be unsuitable as a drinking water supply. Isolated areas of Washington State have naturally occurring levels of one or more inorganic chemicals (e.g., iron, manganese, or arsenic) above the standard set for drinking water. In addition, aquifer contamination has resulted from wide-scale human activity (e.g., agricultural activity resulting in nitrate contamination) in certain areas. In these instances, groundwater treatment would be necessary to reduce the level of the contaminant(s).

Drinking Water Quality

Toxic chemicals discharged into the environment over the years are being found in drinking water. Pesticides, fertilizers, and industrial solvents are examples of these chemicals. In response to the growing awareness of the health threats these chemicals may pose, new laws require water systems to monitor and remove many of these chemicals.

The adage, "An ounce of prevention is worth a pound of cure," is certainly true of drinking water. In general, it is far less costly and complicated to prevent contaminants from entering drinking water than it is to remove them. We all need to do our part to ensure the protection and preservation of existing and future drinking water sources.

This section will discuss some of the contaminants that can be found in drinking water. The following topics will be covered:

- Risk assessment;
- Drinking water quality standards;
- Sampling and testing drinking water; and
- Microbiological, chemical, physical and radiological characteristics of water.

Risk Assessment

Drinking water standards are based in part on health effects information for each contaminant. Risk assessment is the process used to evaluate the potential for contaminants in drinking water to cause health problems in people. This section discusses the concept of risk, the risk assessment process, and how it relates to the establishment of drinking water standards.

What is Risk?

Environmental risk is the likelihood of injury, disease, or death resulting from human exposure to a potential environmental hazard. Risks can be voluntary (such as smoking) or involuntary (such as exposure to chemicals from a nearby industrial plant). Risks can also be classified as natural or artificial.

What is Risk Assessment?

Risk assessment is commonly used to evaluate the likelihood that health problems will occur when people are exposed to a particular chemical. Risk assessments blend science, experience, and professional judgment to produce an estimate of potential risk. Chemicals differ in the types of health problems they can cause and in the amount of exposure it takes to cause the illnesses. The types of health problems caused by a chemical depends on the amount of exposure, how often the exposure occurs, and how sensitive a person is to the harmful effects of the chemical. Tables 2 through 4 show that health effects are quite variable and specific to each chemical.

Why Use Risk Assessments?

Risk assessment provides a standardized method to incorporate scientific data into decisions affecting people's health. Risk assessments provide information about health hazards to help establish drinking water standards, regulate toxic chemicals in the environment, establish priorities for cleanup activities, and educate the public about chemical risk.

How Does Risk Assessment Work?

For chemical hazards, the risk assessment process usually consists of four steps:

1. Scientific information about the harmful effects of the chemical is evaluated to determine what types of health problems, if any, the contaminant is capable of causing.
2. The relationship between the amount (or dose) of the chemical and the health consequences is evaluated; typically, the larger the dose, the greater the chance that health problems will occur.
3. People's exposure to the contaminant is evaluated. For chemicals in drinking water, the amount of water consumed is usually the most important consideration. However, certain chemicals enter the air and can be inhaled when people shower or take baths.
4. Information from the first three steps is used to calculate the magnitude of the problem. The final result of the risk assessment process is an estimate of the risk that a health problem may occur if someone is exposed to the contaminant.

Risk Assessment and Drinking Water Standards

How are risk assessment and drinking water standards related? The risk assessment provides a basis for establishing how clean drinking water must be to protect public health. It helps determine a contaminant level at which no known or anticipated health effect will occur. This level is considered an ideal health goal that is not enforceable. Enforceable drinking water standards are set as close to the ideal health goals as are feasible.

Standards and Testing

Over the past few decades, significant advances have been made in laboratory capability. These advances allow scientists to measure chemicals in drinking water at very low levels. This ability, coupled with increased understanding of the potential health risks associated with exposure to chemicals, has led to today's drinking water standards.

Standards are set by the federal government to ensure the water you consume is safe and aesthetically pleasing. The standard defines the maximum amount of a contaminant allowed in drinking water. This level is referred to as the maximum contaminant level (MCL). If a contaminant is in water at a level higher than the MCL, the water must be treated to reduce or eliminate the contaminant.

Drinking water standards fall into two categories: primary and secondary. Primary standards are based on the potential health effects of contaminants, laboratory capability, availability and cost of treatment, and economic and regulatory impacts. Secondary standards are based on aesthetic properties such as taste, odor, and appearance.

Substances found in drinking water are classified as: microbiological, chemical, physical, and radiological. These are discussed in more detail in the next chapter.

Water quality monitoring plays an important role in protecting public health. As mentioned previously, public water systems are required to monitor routinely for microbiological and chemical contaminants to verify that standards are being met. Monitoring frequency is determined by the system size, population served, source type and use.

A water quality sample with satisfactory laboratory results now does not guarantee the future quality of the water. This is why monitoring must be conducted on an ongoing basis.

Individual water supplies serving a single household are not required to be monitored. However, homeowners are encouraged to test their water for microbiological and inorganic chemicals when their wells are first drilled. Periodic (once a year) microbiological analysis and nitrate analysis (every three years) are also recommended. Contact your local health agency for further information on testing individual water supplies.

Substances of concern in drinking water can occur in amounts that cannot be seen, smelled, or tasted. The presence of these substances is determined by laboratory testing. Water samples must be carefully collected, shipped, and analyzed so the results accurately reflect the quality of the water being tested.

Scientific research has developed standard methods for collecting, transporting, storing, and testing drinking water samples. Scientists and technicians who analyze these samples must have extensive education and training. In addition, laboratory staff must be able to operate and maintain the special equipment needed to test drinking water. Laboratories must be certified by Ecology to ensure they have proper equipment, trained staff, and good quality control procedures.

Quick, in-home water quality tests should not replace testing by a certified laboratory. In-home tests may not be as precise as laboratory tests and the results may be misunderstood. Also, in-home tests cannot detect the presence of many health-related contaminants such as organic and inorganic chemicals. In general, in-home tests are not recommended to determine the quality or safety of your drinking water.

Microbiological Characteristics

Safe drinking water must be free of disease-causing microorganisms. Bacteria, viruses, and protozoans are examples of pathogens that can cause waterborne diseases such as hepatitis, giardiasis, and dysentery. Pathogens in drinking water usually originate in the feces of humans or other warm-blooded animals.

Laboratory tests have been developed to analyze the microbiological quality of drinking water. These tests do not examine the water for the presence of pathogens. Instead, a group of largely nonpathogenic bacteria called "coliforms" is used to indicate the microbiological quality of drinking water.

Coliform bacteria are used as water quality indicators for two main reasons. First they are normally present in large numbers in the intestines of humans and other warm-blooded animals. Thus, coliforms originate from the same source (feces) as many pathogens. Secondly, laboratory tests for coliforms are relatively simple and inexpensive to conduct compared to the tests for specific pathogens.

Drinking Water Microbiological Results

If coliform bacteria are found in a drinking water sample, the laboratory report is marked as unsatisfactory. The presence of coliforms indicates possible contamination. Samples that are positive for total coliform bacteria are also tested for E. coli or fecal bacteria.

Public water systems receiving unsatisfactory microbiological results are required to take additional water samples, notify customers, and take corrective action to protect public health. If contamination is confirmed, the customers must be notified and the level of public health risk must be conveyed in the notice. The water system manager should inspect the water system and correct any deficiencies that may have allowed contamination to enter the water system. Chlorine may be added to the water system on a temporary or permanent basis to disinfect the water system. Owners of individual water supplies receiving unsatisfactory results should contact their county health agency to determine what action should be taken.

In recent years, one waterborne infection, giardiasis, has received increased attention. This infection is nicknamed beaver fever. This intestinal illness causes diarrhea, abdominal cramps, and nausea that last one or more weeks and periodically reoccurs. If you have giardiasis, your doctor can prescribe a drug to treat it.

The microorganism (*Giardia lamblia*) that causes giardiasis is the most commonly found intestinal parasite in the United States. One way people can get giardiasis is by drinking water contaminated by animal or human feces, commonly spread through contact with pets, and by people who do not wash their hands after changing diapers.

Giardiasis can be prevented. People should avoid drinking water directly from rivers, streams, and lakes. Campers and backpackers should carry their own "safe" water or purify surface water prior to use. Boiling, disinfection with chlorine or iodine, and filtration are all effective treatment methods. Contact DOH or your local health agency for more information.

Chemical Characteristics

Chemicals can be classified into two groups. Those that contain carbon are called organic chemicals; those that do not are called inorganic chemicals. The term "organic" reminds us that many of these chemicals consist of animal or plant origin. Organic compounds contain carbon in combination with one or more elements such as hydrogen and oxygen. There are over three million known organic compounds and the number is increasing. These compounds have either been made in the laboratory or obtained from nature.

Unlike organic chemicals, inorganic chemicals are often associated with rocks, clay, sand, and other earthy materials. Natural processes such as weathering and soil leaching, as well as human activities, are sources of inorganic materials in drinking water.

Inorganic Chemicals

Public water systems are required to monitor their drinking water for inorganic chemical characteristics. These chemicals are divided into two groups, primary and secondary, which correspond to the primary and secondary standards previously discussed. Table 2 lists the primary inorganic contaminants, their sources, and adverse health effects. Table 3 lists the secondary inorganic contaminants, their sources, and aesthetic effects.

Organic Chemicals

Public water systems are also required to monitor for organic chemicals. Many organic chemicals are synthetic, i.e., produced by humans. Synthetic organic chemicals are often used in industry (solvents and petroleum byproducts) and agriculture (pesticides). Many of these chemicals are toxic at low concentrations and are measured in micrograms per liter (ug/L) or parts per billion (ppb).

In terms of current drinking water regulations, organic chemicals are divided into two basic groups: 1) pesticides and other volatile (evaporate easily) and nonvolatile organic compounds, and 2) disinfection byproducts including trihalomethanes. Table 4 provides a general description of the sources and health effects of these two major groups of organic chemicals.

More detailed information on specific organic chemicals in drinking water (including maximum contaminant levels and health effects) is available from DOH.

Table 2. Primary Inorganic Chemical Contaminants

Contaminant	MCL[1] (mg/L)	Sources	Principal Health Effects
Antimony	00.6	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	Increased blood cholesterol and decreased in blood sugar.
Arsenic	0.01	Erosion of natural deposits; runoff from orchard, runoff from glass and electonics production wastes	Skin damage or problems with circulatory system; may have an increased risk of getting cancer
Asbestos MFL (million fibers/liter)	7 MFL	Decay of asbestoos cement water mains; erosion of natural deposits	Increased risk of developing benign intestinal polyps.
Barium	2	Discharge drilling wastes; discharge from metal refineries; erosion of natural deposits	Increase in blood pressure.
Beryllium	.004	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	Development of intestinal lesions.
Cadmium	.005	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	Kidney damage
Chromium	.1	Discharge from steel and and pulp mills; erosion of natural deposits	Allergic dermatitis.
Copper	AL[2] = 1.3	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives	Gastrointestinal distress, liver, or kidney damage.
Cyanide	.2	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	Nerve damage or problems with thyroid.

[1] The maximum contaminant level (MCL) is the highest allowable level of a chemical contaminant in drinking water. One milligram per liter, mg/L, equals one part per million.

[2] AL = Action level. For lead and copper, the Environmental Protection Agency has established distribution system related levels at which a system is required to consider corrosion control. These levels, called "action levels," are 0.015 mg/L for lead and 1.3 mg/L for copper.

Table 2. Primary Inorganic Chemical Contaminants - continued

Contaminant	MCL[1] (mg/L)	Sources	Principal Health Effects
Fluoride	4	Erosion of natural deposits; Water additives which promotes strong teeth; discharge from fertilizer factories	Nerve damage or problems with thyroid.
Lead	AL[2] = .015	Corrosion of household plumbing systems; erosion of natural deposits	Central and peripheral nervous system, and kidney damage; high blood pressure.
Mercury (inorganic)	.002	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland	Central nervous system and kidney damage
Selenium	0.01	Paint, rubber, and insecticides	Skin and gastrointestinal damage.
Silver	0.05	Naturally occurring	Skin discoloration
Nitrate	10	Runoff from fertilizer use; Leaching from septic tanks, sewage; erosion of natural deposits	Reduces blood's ability to carry oxygen in infants below the age of 12 months. Causes blue-baby syndrome.
Nitrite	1	Runoff from fertilizer use; Leaching from septic tanks, sewage; erosion of natural deposits	Reduces blood's ability to carry oxygen in infants below the age of six months. Causes blue-baby syndrome.
Selenium	0.5	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	Hair or fingernail loss; numbness in fingers or toes; circulatory problems.
Sodium	***	Natural deposits, urban run-off and saltwater intrusion	Increased blood pressure
Thallium	.002	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	Hair loss, changes in blood, kidney, intestine, or liver problems.

*** Although there is no established MCL for sodium, there is enough public health significance associated with sodium levels to require inclusion in inorganic chemical and physical monitoring. The Environmental Protection Agency has established a recommended level of 20 mg/L for sodium as a level of concern for those consumers that may be restricted for daily sodium intake in their diets.

Table 3. Secondary Inorganic Chemical Contaminants			
Contaminant	**MCL[1] (mg/L)**	**Sources**	**Principal Health Effects**
Chloride	250.0	Natural deposits, urban run-off, seawater intrusion	Objectionable taste and corrosion of pipes
Fluoride	2.0	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories	Tooth discoloration
Iron	0.3	Naturally occurring, corrosion of pipe	Objectionable taste and odor, discolors laundry and fixtures
Manganese	0.05	Naturally occurring	Objectionable taste and odor, discolors laundry and fixtures
Silver	.1	Naturally occurring; industrial waste	Skin discoloration, graying of white eyes
Sulfate	250.0	Natural deposits and wastewater	Objectionable taste, laxative effect
Zinc	5.0	Corrosion of pipe material	Objectionable taste, corrosion of pipes

[1] The maximum contaminant level (MCL) is the highest allowable level of a chemical contaminant in drinking water. One milligram per liter, mg/L, equals one part per million.

Table 4. Primary Organic Chemical Contaminants		
Contaminant	**Sources**	**Principal Health Effects**
Pesticides	Agricultural, industrial, and home uses	Some damage the liver, kidneys, respiratory and/or nervous system. Some may cause cancer in humans.
Other organic compounds	Solvents, varnishes, glues, and industrial and petroleum by-products	In general, they damage the liver and kidneys. Some may cause cancer in humans.
Disinfection byproducts	Byproduct of disinfectants reacting with natural organic materials*	Some damage liver, kidneys and blood system. Some may cause cancer in humans.

* Disinfection is the primary means of inactivating harmful microorganisms to prevent waterborne disease outbreaks.

Physical Characteristics

The physical characteristics of water include color, specific conductivity, and total dissolved solids. Table 5 describes these characteristics.

Table 5. Physical Characteristics		
Contaminant	**Secondary MCLs[1]**	**Adverse Effects**
Color	15 Color Units	Visible tint
Specific Conductivity	700 umhos/cm[2]	Hardness; deposits; colored water
Total Dissolved Solids	500 mg/L	Hardness; deposits; colored water; stale taste

[1] The maximum contaminant level (MCL) is the highest allowable level of chemical contaminant in drinking water. One milligram per liter, mg/L, equals one part per million.

[2] Umhos/cm = micromhos per centimeter at 25° C

Radiological Characteristics

Radionuclides are radioactive decay products that can be naturally occurring or humanmade. Radionuclides of concern to public health are radium, uranium, and radon.

Of these three, radon is the greatest health concern. Radon, a colorless, odorless, and tasteless gas, is a product of the natural decay of uranium in soil and rock. Most of the radon in indoor air comes from soil underneath the home. As uranium breaks down, radon gas forms and seeps into the house. The public health concern is that breathing radon in indoor air can cause lung cancer.

Radon gas can also dissolve and accumulate in groundwater. When water that contains radon is used in the home for showering, washing dishes, and cooking, radon escapes from the water and goes into the air.

Radon is not a concern in water that comes from surface water (e.g., lakes, rivers, and reservoirs) because the radon is released into the air before it arrives at your tap.

Facts the Consumer Should Know

Many factors determine whether contaminants may be in drinking water. These factors include the nearness of your source of water to potential sources of contamination, the type of water source (for example: groundwater, or rivers, lakes, and streams) and whether your water is treated. For some contaminants (such as lead and copper), the physical and chemical properties of the water, and the material used in the distribution system and home plumbing may also be factors. So, just because drinking water in one geographic area or individual home is contaminated, it doesn't mean your drinking water is also contaminated.

It is important to understand that contaminants can be present in water at levels that may not be high enough to cause adverse health effects. Remember that health risks depend on many factors including the type of contaminant, how much is present in the water, the vulnerability of the person drinking the water, and the length of time the person drinks water containing the contaminant.

Water System Operation

Water Treatment

Most drinking water sources must be treated prior to distribution to customers. The objective of treatment is to provide high quality drinking water, which can be achieved by using various treatment processes that are selected based on source water quality.

Table 6 lists some common water treatment processes and their respective uses. Each process serves a specific purpose. Filtration and disinfection are two of the most commonly used treatment processes. Figure 4 shows a typical treatment scheme for a surface water source.

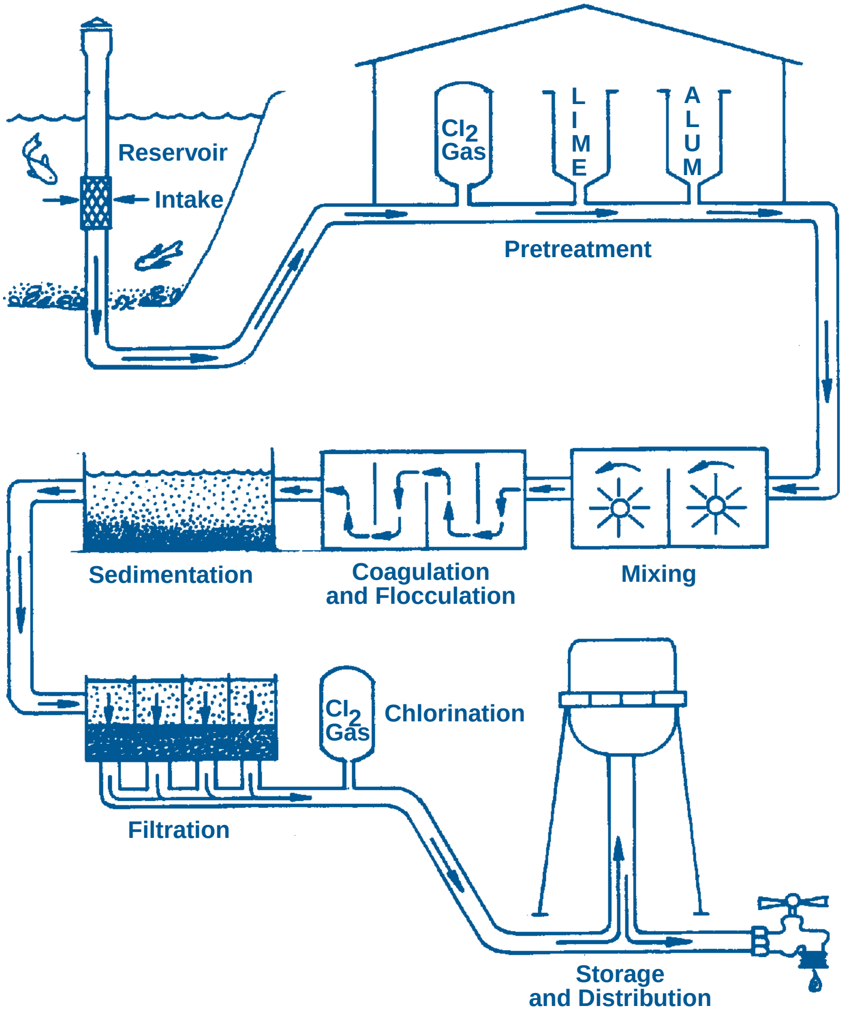
Treatment plants and water distribution systems should be properly operated and maintained to assure production and delivery of safe drinking water. This is why many public water systems are required to have certified operators. To become certified, plant operators must demonstrate their knowledge of treatment processes, public health protection, and state drinking water regulations, and meet professional growth requirements.

As more stringent laws are adopted, more systems will be required to provide treatment. For most public water systems, centralized water treatment provides health protection and is less costly than treatment at each service connection. DOH has guidance on where individual treatment units at your tap may be appropriate.

Home treatment requires homeowners to get into the water treatment business. Without proper installation, operation, and maintenance, some units can produce water of lower quality than the water being treated. Periodic testing helps ensure that treatment units are working properly. In addition, these devices can be expensive to install, maintain and test.

Table 6. Typical Water Treatment Processes	
Process	**Purpose**
Preliminary Treatment	
Screening	Removes large debris
Chemical Pretreatment	Conditions the water to remove algae that can cause taste, odor, and color
Main Plant Processes	
Aeration	Removes odors and dissolved gases, improves taste; first step in iron and manganese removal
Coagulation/ flocculaiton	Allows particles to settle and filter more easily
Sedimentation	Removes settleable particles
Softening	Removes chemicals that cause water hardness
Filtration	Removes particals and most microorganisms
Adsorption	Removes organics and color
Fluoridation	Adds fluoride to prevent tooth decay
Stabilization	Prevents corrosion and scaling
Disinfection	Kills disease-causing organisms

Figure 4. Typical Surface Water Treatment Plant



Corrosion and Lead

Water at your faucet may contain higher levels of dissolved metals than the water in the distribution system. Metals can get into drinking water from corrosion of home plumbing.

Corrosion refers to the gradual deterioration of a material due to a reaction with its environment. In the context of drinking water, the "materials" are the distribution and home plumbing systems, and the "environment' is drinking water. Corrosion can impact health, produce colored water, cause taste problems, and increase a utility's cost of providing water.

Lead is a toxic metal that can occur in drinking water as a result of corrosion. Lead can accumulate in the body; so low-level exposure over time can pose a significant health threat. Infants and children up to six years old are most susceptible. Pregnant women exposed to lead can pass the effects to their unborn child. Exposure for adults primarily affects the peripheral nervous system and can cause impairment of hearing, vision, and muscle coordination. The major sources of lead in drinking water are the pipes, fittings, and the solder and flux used to seal joints and connections in home plumbing systems.

There are several ways to lower levels of lead and other metals in drinking water. These include:

- Reducing how corrosive the water is;
- Using lead-free materials (state law since 1987);
- Cleaning the screens and aerators in faucets frequently to remove captured lead particles;
- Flushing stagnant water from the home plumbing system before drawing water for drinking.
- Using cold water for drinking, cooking, and making baby formula. Hot water may contain higher levels of lead.

The only way to know the amount of lead in your household water is to have your water tested by a certified laboratory. Testing for lead costs about $30 per sample.

Cross-Connection Control

A cross-connection is a physical link between a drinking water system and a potential source of contamination. Microbial, chemical and /or physical contaminants can enter the public water system via cross-connections under certain conditions (i.e., backflow). Backflow is the undesirable reversal of flow from the customer's plumbing system into the public water system.

Backflow conditions can occur when pressure in the public water system drops below the customer's plumbing system pressure (backsiphonage), or the customer's plumbing system pressure is raised above the public water supply pressure (backpressure). In either case, if contaminants are introduced into the public water system, the health of consumers served by the system is at risk. Depending on the contaminant, backflow incidents can cause disease, infection, injury, and/or death.

To protect public health, state drinking water regulations require purveyors to develop and implement cross-connection control programs. Cross-connection control programs isolate, using backflow preventers, potential source(s) of contamination from the public water system. Physical separation (air gap) and installation of mechanical backflow prevention assemblies are the most commonly used backflow prevention methods. Backflow preventers may be installed at the meter for premises isolation or at the hazardous fixture to protect the public water system from contamination. The Uniform Plumbing Code requires homeowners to install backflow preventers at fixtures (e.g., residential boilers) to protect the homeowner's plumbing system from contamination.

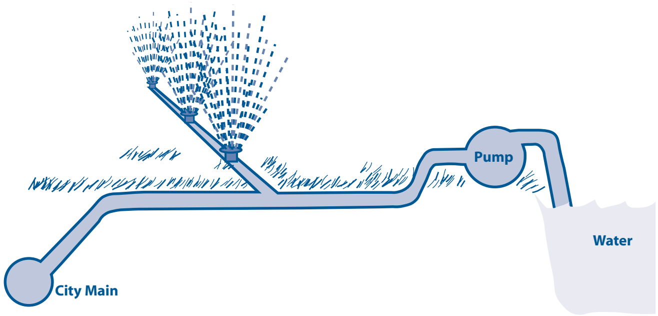
Figure 5. Examples of Typical Residential Cross-connections

1. The free end of a hose being submerged in a filled sink, basin or swimming pool, when the other end of the hose is attached to the household plumbing.
2. A chemical sprayer containing hazardous lawn and/or garden chemicals being mounted on the end of a garden hose attached to the household plumbing.

Example 1

Example 2

3. A private well or other water source such as a pond or lake (i.e., auxiliary water supply) that is connected to the household plumbing (often through an irrigation system) in addition to the purveyor's supply.



Example 3

Homeowners can often eliminate cross-connections to protect their drinking water. In Example 1, the homeowner can simply remove the submerged end of the hose from the source of contamination and make sure a physical separation always exists between the hose and the surface of the unsafe water. Homeowners can avoid creating the cross-connection described in Example 2 by avoiding the use of chemical sprayers that attach to the household supply. In Example 3, homeowners can protect their drinking water by not connecting the auxiliary supply to the household plumbing. Where the homeowner's auxiliary supply is interconnected with the household plumbing in addition to the purveyor's supply, purveyors must require a backflow preventer to be installed at the meter to protect the public water system from contamination.

Emergency Drinking Water

In spite of our best efforts, drinking water emergencies can and do occur. Water sources can become contaminated. Treatment equipment may break down. Water pipes may leak or break, or backflow may occur through an unknown cross-connection. During an emergency, if the safety of a drinking water supply is questionable, take appropriate action to protect health.

In most drinking water emergencies, the main concern is that harmful microorganisms may have contaminated the water. In such cases, the public water system issues a boiled water notice. The notice instructs customers to boil their drinking water until the problem is corrected.

Homeowners served by individual supplies can also take action in emergencies to protect health. Obtaining water from a safe source on a temporary basis is one option. Boiling the water for three to five minutes is another option. Using unscented liquid chlorine household bleach can also be an effective emergency treatment method.

Disinfection with bleach may be more practical than boiling when larger volumes of water need to be treated. Follow the instructions provided below.

Treating Water With a 5-6% Liquid Chlorine Bleach Solution

(Allow treated CLEAR water to stand 30 minutes before using; treated CLOUDY water to stand for 60 minutes)

Volume of Water To Be Treated	Treating Clear Water Bleach Solution To Add	Treating Cloudy, Very Cold or Surface Water Bleach Solution To Add
1 quart/1 liter	3 drops	5 drops
1/2 gallon/2 quarts/2 liters	5 drops	10 drops OR 1/8 tsp
1 gallon	10 drops OR 1/8 tsp	20 drops OR 1/4 tsp
5 gallons	50 drops OR 2.5 mL OR 1/2 tsp	5 mL OR 1 tsp
10 gallons	5 mL OR 1 tsp	10 mL OR 2 tsp

tsp = teaspoon; Tbsp = tablespoon; mL = milliliter

1. From the above table, determine amount of bleach to add. If the water is off-color or cloudy, use double the amount of bleach shown in the table.
2. Add the bleach to the water and mix.
3. Let the mixture stand for 30 minutes prior to use. Waiting 30 minutes is very important, because the chlorine needs this time to kill any harmful organisms.

Treat water for making drinks, preparing food, or brushing teeth the same as water for drinking. Once disinfected, store water only in clean containers.

Boiling and disinfection generally affect only the microorganisms in the water. If you suspect your drinking water is contaminated with harmful chemicals, contact your local health agency or DOH for advice.

Conclusion

As more people move to Washington, the demand for safe drinking water increases. The Office of Drinking Water encourages people to connect to existing, large public water systems (serving more than 1,000 connections) rather than creating new small systems. To get a list of those in your area, contact the appropriate DOH regional office listed on page 30.

Small systems face greater challenges in meeting many aspects of the Safe Drinking Water Act than larger systems. Larger systems have a larger customer base that helps defray the overall costs than smaller systems. Thus, connecting to a large system will generally provide greater health protection at a lower cost to consumers. In those instances where it is not possible or practical to link into an existing public water system, contact DOH or your local health agency for information.

Providing safe drinking water is a very complex task that can no longer be taken for granted. Protecting our water supplies from contamination will require an increased commitment from many people working together. We strongly encourage you to learn as much as you can about your drinking water supply and join in accepting responsibility for ensuring safe drinking water for the future.

One way consumers can educate themselves about their drinking water is by reading their annual consumer confidence report. Water systems are required to produce these reports for their customers annually. The reports advise consumers of any contaminants found in their drinking water and how these contaminants may affect their health. The report also contains information about where their drinking water comes from, so that consumers can get involved in protecting or improving their drinking water resource.

If you would like more information on the topics discussed in this booklet, you can contact DOH, your local health agency, or browse your local public library or bookstore. Many books and journal articles have been written about drinking water topics and a reference librarian should be able to help you find them.

Publications and Contacts

Publications available upon request from your DOH Office of Drinking Water cover the following subjects:

- Emergency Response/Security
- Engineering Design/Water Treatment
- Management/Funding
- Operations/Maintenance
- Planning/Financial Viability
- Regulations/Operator Certification
- Water Quality/Source Protection
- Water Use Efficiency/Water Re-Use
- General information

Publications are available on our Web site at www.doh.wa.gov/ehp/dw/Our_Main_Pages/public.htm.
You may also call the Training and Outreach Section at 360-236-3164, or leave a message on our toll-free number: 800-521-0323.

Drinking Water Information Contacts

For more information about drinking water, contact your local health agency, Department of Health, the U.S. Environmental Protection Agency, or Department of Ecology. Addresses, phone numbers and Web addresses are provided below.

Washington State Department of Health
Office of Drinking Water
PO Box 47822
Olympia, WA 98504-7822
360-236-3100 or 800-521-0323
www.doh.wa.gov/ehp/dw

Southwest Regional Office
PO Box 47823
Olympia, WA 98504-7823
360-664-0768

Eastern Regional Office
1500 West 4th Avenue, Suite 305
Spokane, WA 99204
509-456-3115

Northwest Regional Office
20435 72nd Avenue South, Suite 200
Mail Stop K17-12
Kent, WA 98032
253-395-6750

U.S. Environmental Protection Agency (EPA)
Hotline 800-426-4791
www.epa.gov/OGWDW

Washington State Department of Ecology
PO Box 47600
Olympia, WA 98504-7600
360-407-6000
www.ecy.wa.gov

Local Health Agencies

Adams County Health District, 509-659-3315
Asotin County Health District, 509-758-3344
Benton-Franklin Health Department, 509-943-2614
Chelan-Douglas Health District, 509-886-6400
Clallam County Health Department, 360-417-2274
Clark County Health District, 360-397-8215
Columbia County Health District, 509-382-2181
Cowlitz Health District, 360-414-5599
Garfield County Health District, 509-843-3412
Grant County Health District, 509-754-6060
Grays Harbor Health Department, 360-532-8665
Island County Health Department, 360-679-7350
Jefferson County Health Department, 360-385-9400
Kitsap County Health Department, 360-337-5235
Kittitas County Health Department, 509-962-7515
Klickitat County Health Department, 509-773-4565
Lewis County Health Department, 360-740-1223
Lincoln County Health Department, 509-725-1001
Mason County Health Department, 360-427-9670
Northeast Tri-County Health District, 509-684-1301
Okanogan County Health District, 509-422-7140
Pacific County Health Department, 360-875-9343
Public Health Seattle-King County, 206-296-4600
San Juan County Health Department, 360-378-4474
Skagit County Health Department, 360-336-9380
Snohomish Health District, 425-339-5200
Spokane County Health District, 509-324-1500
Tacoma-Pierce County Health Department, 253-798-6500
Thurston County Health Department, 360-786-5581
Wahkiakum County Health Department, 360-795-6207
Walla Walla County-City Health Department, 509-527-3290
Whatcom County Health Department, 360-676-6720
Whitman County Health Department, 509-397-6280
Yakima County Health District, 509-575-4040

Washington State Department of Health
Division of Environmental Health
Office of Drinking Water

Washington State Department of Health
Office of Drinking Water
PO Box 47822 Olympia, Washington 98504-7822
www.doh.wa.gov/ehp/dw